Prospects for the use of advanced computer modeling systems in planning geological and technical activities

Ruslan Gilyazetdinov [1*]

[1]Institute of Oil and Gas FSBEI of HE "Ufa State Petroleum Technological University", (Branch in the City of Oktyabrsky), 54a, Devonskaya Street, Oktyabrsky, Republic of Bashkortostan, 452607, Russia

Abstract. In this paper, the authors conducted a theoretical study devoted to assessing the prospects for using modern computer modeling systems to solve one of the key tasks of oil field development – planning effective geological and technical measures. At the moment, operations to increase the productivity of wells play a crucial role in achieving project targets for the extraction and rational use of natural resources. Significant interest in digital support of geological and technical activities is due to the increase in the number of software and hardware complexes used in the field of oil production and the positive results of their application. Using the example of repair and insulation works, the methodology of developing a system that allows reasonably selecting candidate wells based on the analysis of geological and field data is presented. The conclusion is made about the most important factors influencing the effectiveness of geological and technical measures.

1 Introduction

At the present stage of the development of the oil industry, the subsoil users of the main objects of the country's raw material base, represented in the form of large oil-bearing provinces, face many technological difficulties due to the fact that hydrocarbon deposits are entering the final stage of development. There is widespread use of mechanized methods of lifting liquid to the surface due to depletion of reservoir energy and, as a result, the occurrence of various kinds of complications during operation wells [1-4].

An important role from the point of view of fulfilling the project indicators for production is occupied by work complexes related to the restoration of functioning wells and productive formations by various operations. About 15-20 years ago, the lion's share of capital works at wells was occupied by physico-chemical, mechanical and thermal effects on the bottom-hole zone of the formation, the introduction of installations for simultaneous separate operation, simultaneous separate injection, drilling of lateral and horizontal shafts in order to involve previously undrained oil and gas reserves. This was due to the need to

* Corresponding author: gilyazetdinov_2023@mail.ru

build up the potential of deposits ahead of time relative to the development periods and to some extent was a prerequisite for even more intensive wear of downhole equipment [5-8].

We can observe the opposite situation over the past 5-10 years, when in the field of oilfield services, in addition to a multiple increase in the number of GTMs carried out, there is a high demand for the amount of work associated with disconnecting various layers or intervals of the facility, restoring and building up cement supports behind casing columns (conductor, intermediate column (technical), operational column). The presented trend forces subsurface users to place increased demands on the repair work carried out in the borehole –formation system due to the unstable filtration-capacity and energy state of deposits.

2 Methods and materials

Repair and insulation works are a set of technological operations to prevent the entry of water, sand or a mixture into a corrosive object (well) and its operation zone (annular space), disconnecting layers, intervals, and the build-up of a cement ring behind the casing from it for various reasons. This type of geological and technical measures, together with additional well operations, is one of the methods of implementing work to increase the oil recovery coefficient, protect the subsoil and the natural environment [9-11].

The inclusion of repair and insulation operations in the modern list of key technologies necessary to restore and increase productivity (increase the inter-repair period) of wells in conditions of low downhole pressures is a forced method of regulating oil recovery of depleted facilities. At the same time, a key component of the trend of increasing the percentage of repair and insulation work carried out at the fields is not only the construction of wells of complex design with a large deviation from the vertical, which drain poorly permeable and complex oil formations (deposits) related to transitional oil and water facilities with a powerful gas cap, but also significant changes regarding the development of hard-to-recover reserves and their subsequent extraction [12-14].

An important addition to the above reasons for the massive RIW at wells is the fact that the reservoir pressure maintenance system, which is equipped with more than 50% of hydrocarbon deposits, has not undergone drastic changes in technology and equipment since the 80s. The development of oil facilities using various types of flooding implies a high selection of produced waters along the way until the water content of 98% or more is reached. The analysis of thematic literature sources in conjunction with the study of field material confirms the following assumption: at the current stage of development of oil fields in the Russian Federation, approximately 35% of the injected agent through the MRP system does not allow oil to be fully displaced to the faces of producing wells. Given the low growth rates of drilling and commissioning of new production wells in the fields, combined with the low reliability of the existing fund due to natural aging, early flooding of productive formations due to the use of a technologically imperfect MRP system and incompatible agents is one of the factors increasing the share of repair and insulation work in total cattle volumes.

The selection of technological schemes and insulating materials for conducting RIR should take into account the goals and objectives of repair, geological, physical and thermobaric conditions in the area of which insulation is necessary. The special requirements for the methodology of conducting the considered type of GTM are as follows:

- To ensure the successful and justified application of repair and insulation technologies that exclude a decrease in the permeability of the bottomhole formation zone and loss of insulating properties of grouting materials due to operations to change or mix the composition of solutions.

- To fill the well space only with a homogeneous composition in density.
- Use working fluids whose density is greater than the density of the borehole fluid.
- The creation of artificial insulation screens in a corrosive environment of an object (well) should be conditioned from the point of view of the "insulation interval-matrix of rocks-productive formation" system and meet the requirements of industrial safety and labor protection.

Many scientists in their work related to the optimization of oil production using geological and technical measures have noted that the solution to the problem of implementing effective MOONS in modern fields includes [15-16]:

- In-depth analysis of planning issues, justification of conditions and methods of GTM.
- Estimates of the possible potential of this method of increasing oil recovery for each specific well, with further preliminary grouping of them according to the main characteristics: reservoir type, exploited horizon, type of DWT, etc. (depending on the requests of the subsurface user).

As a result, a basic (universal) procedure for determining the possibility of implementing geological and technical measures at a specific facility (well) has been formed. If we consider its applicability to repair and insulation work, then some uncertainties and risks arise that affect the final result. Studying the process of limiting water inflows into wells from the point of view of restoring technical condition, it can be noted that in this case, the sign of successful repair will be the operation of the DWT in the permissible range without complications with achieving the requirements of subsurface and environmental protection. Otherwise, when studying this problem from the perspective of reducing the amount of produced water, the question arises as to what criteria to follow when evaluating the effectiveness of well operations.

3 Results and Discussion

Taking into account the domestic and international experience of conducting ORP activities over the past decade, we present graphically a curve that approximates the priority of the factors determining the success of GTM at various stages of field development (Figure 1).

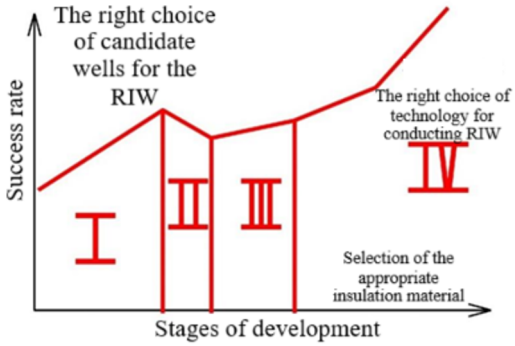

Fig. 1. Graphical representation of the most important factors for planning successful geological and technical activities.

The most common reasons for obtaining a negative result in the implementation of borehole operations to limit water inflow include insufficient reasonable and accurate selection of candidates and, consequently, the erroneous application of a particular technology in the geological and physical conditions of the selected object. Another important reason for ineffective repair and insulation work at the current stage of well operation is the lack of knowledge of the geological features of an object when choosing a

method for selecting candidate wells, technologies and materials to limit water inflow. This problem is complex in nature for the following reasons. First of all, the quality of planning and further implementation of insulation works is influenced by the reliability of a systematic approach to the choice of methods and means, as well as to justify the required amount of insulation materials, its types and characteristics.

According to the research results, more than half of the oil and oilfield service companies in the Russian Federation do not attach such high importance to the above attributes compared to their foreign counterparts [9]. The availability of an extensive amount of historical information about the object allows not only to avoid uncertainties when planning a portfolio of geotechnical measures in order to intensify the processes occurring in the productive reservoir, but also contributes to making the right decisions when choosing techniques and technologies to limit the amount of associated produced water.

Summarizing the above comprehensive analysis of the problem of the effectiveness of works to limit water inflow, it can be established that the trend of implementing schemes for selecting candidate wells in the modern oil and gas complex of the Russian Federation is limited by insufficient knowledge of the initial information and the lack of methods and means of processing an array of data suitable to the specifics of the industry in question. The consequence of this is decision-making based on secondary data, which does not allow for a proper assessment of factors and risks. The desire of subsurface users to digitalize oil and gas production facilities can become the foundation for the implementation of high-precision multi-level systems.

4 Conclusion

The geological success of repair and insulation works is determined by the conditional value of geological efficiency (achievement of the calculated increase in flow rate), due to the reliability of the obtained geophysical data and other factors (correctness of calculations of expected parameters: geological potential, waterlogging, etc.). Assessment of the technological success of the implementation of works on the isolation of water inflow is associated with a number of difficulties arising both during the RIW, and directly during its planning. Confirmation of the technological success of the well operation to isolate the inflow is confirmed by the results of geophysical studies and the parameters of the well operation when it is put into operation.

The expediency of implementing measures for insulation works depends on the general condition and efficiency of the development system of the facility (field). Currently, in field practice, there are many methods and criteria for selecting potential wells for RIW, each of which has its advantages and disadvantages. Using only one algorithm in conditions of a large data set is an incorrect strategy due to the fact that they are supporting tools, the use of which implies ranking wells according to the criterion of the need for repair. Based on this, the most important component of planning effective geological and technical measures is the use of advanced computer systems, which will reduce the risks of making managerial decisions under various constraints.

References

1. S. Mingulov, V.S. Mukhametshin, R. Vafin, R. Gilyazetdinov, D. Kobishcha, The effect of the viscosity of borehole products on the operation of pumping equipment and the coefficient of oil recovery, E3S Web of Conferences, **494**, 02010 (2024)

2. V. Shchetnikov, V.V. Mukhametshin, L. Kuleshova, R. Gilyazetdinov, M. Veliev, A. Gizzatullina, Intensification of oil production using enzyme solutions, E3S Web of Conferences, **494**, 02008 (2024)
3. V.S. Mukhametshin, L. Kuleshova, R. Yakupov, R. Vafin, R. Gilyazetdinov, Features of localization of remaining oil in terrigenous reservoirs and potential for their recovery at the final stage of field development, E3S Web of Conferences, **480**, 01018 (2024)
4. R. Kadyrov, V.V. Mukhametshin, R. Gilyazetdinov, D. Kobishcha, Technical and technological justification of repair and insulation works at oil fields of the Republic of Tatarstan using special compositions, E3S Web of Conferences, **480**, 01015 (2024)
5. R.R. Kadyrov, L.S. Kuleshova, I.G. Fattakhov, Technologies and technical devices for annual regulated flooding of a productive strata, In International Conference" Actual Issues of Mechanical Engineering"(AIME 2018), 232-235 (2018)
6. R.R. Kadyrov, Prospects of applying formation water and heavy brines derived therefrom in oil production and national economy, IOP Conference Series: Materials Science and Engineering, **905**(**1**), 012081 (2020)
7. E.M. Almukhametova, M.O. Mikhaylov, R.R. Stepanova, Determination of the gas factor of oil at Western Siberia fields, IOP Conference Series: Earth and Environmental Science, **579**(**1**), 012018 (2020)
8. E. Almukhametova, M. Mikhailov, Technological feature of hypan-acid treatment, II International Scientific and Practical Conference “Energy, Ecology and Technology in Agriculture” (EEA2023), **480**, 01010 (2024)
9. A.A. Kochnev, Development of a comprehensive methodology for the forecast of effectiveness of geological and technical measures based on machine learning algorithms, Georesursy, **22.3**, 79-86 (2020)
10. C. L. Li, Application of new geological modeling technology in secondary development in Daqing oil field, IOP Conference Series: Earth and Environmental Science, **40**, 1 (2016)
11. O.Y. Panischev, Neurofuzzy model of formation of knowledge bases for selection of geological and technical measures in oil fields, International Journal of Engineering Research and Technology, **13**(**11**), 3589 (2020)
12. A.V. Stenkin, "Use of low-mineralized water for displacing oil from clay productive field formations, IOP Conference Series: Materials Science and Engineering, **560**, 1 (2019)
13. A.M. Malyarenko, Wettability and formation conditions of reservoirs, IOP Conference Series: Earth and Environmental Science, **378**(**1**) (2019)
14. R.T. Akhmetov, V.V. Mukhametshin. Estimation of displacement coefficient with due account for hydrophobization of reservoir using geophysical data of wells, IOP Conference Series: Earth and Environmental Science, **194**, 6 (2018)
15. V.V. Mukhametshin, Bottomhole formation zone treatment process modelling with the use geological and geophysical information, IOP Conference Series: Earth and Environmental Science, **194**(**2**), 022024 (2018)
16. V. V. Mukhametshin, The need for creation of a unified comprehensive method of geological and field analysis and integration of data on effective influence on the bottom-hole formation zone, Oil Industry Journal. 04, 80-84 (2017)